portion of the actuator remains stationary with respect to the surrounding housing **41** while the moving portion of the actuator and the touchpad move with respect to the housing **41**. The operation of piezo-electric actuators to output force based on an input electrical signal is well known to those skilled the art.

[**0041**] The touchpad **16** can be coupled only to the actuator **42**, or can be additionally coupled to the housing of the computer device at other locations besides the actuators **42**. Preferably the other couplings are compliant connections, using a material or element such as a spring or foam. If such connections are not made compliant, then the touchpad **16** itself preferably has some compliance to allow portions of the pad to move in response to actuator forces and to convey the haptic sensations to the user more effectively.

[**0042**] Since the touchpad **16** is directly coupled to the actuator **42**, any produced forces are directly applied to the touchpad **16**. The electric signal preferably is obtained from a microprocessor and any circuitry required to convert the microprocessor signal to an appropriate signal for use with the actuator **42**.

[**0043**] **FIG. 5** is a side elevational view of another embodiment **50** of the present invention, in which the touchpad **16** is positioned on one or more springs **52**. The springs **52** couple the touchpad **16** to the rigid housing of the computer **10** and allow the touchpad **16** to be moved along the z-axis **56**. Only a very small range of motion is required to produce effective pulses (jolts) or vibrations on the pad **16**. Stops (not shown) can be positioned to limit the travel of the touchpad **16** to a desired range along the z-axis.

[**0044**] An actuator **54** is also coupled to the touchpad **16** to impart forces on the touchpad and cause the touchpad **16** to move along the z-axis. In the present embodiment, actuator **54** is a linear voice coil actuator, where the moving portion (bobbin) of the actuator is directly coupled to the touchpad **16**. The actuator **54** is grounded to the computer **10** housing and outputs a linear force on the touchpad **16** and thus drives the touchpad along the z-axis. A short pulse or jolt can be output, or the moving portion of the actuator can be oscillated to provide a vibration having a particular desired frequency. The springs **52** cause the touchpad **16** to return to a rest position after a force from the actuator causes the touchpad to move up or down. The springs can also provide a compliant suspension for the touchpad **16** and allow forces output by the actuator **54** to be amplified as explained above. Different types of spring elements can be used in other embodiments to couple the touchpad **16** to the rigid housing, such as leaf springs, foam, flexures, or other compliant materials.

[**0045**] In some embodiments, the user is able to push the touchpad **16** along the z-axis to provide additional input to the computer **10**. For example, a sensor can be used to detect the position of the touchpad **16** along the z-axis, such as an optical sensor, magnetic sensor, Polhemus sensor, etc. The position on the z-axis can be used to provide proportional input to the computer, for example. In addition, other types of forces can be output along the z-axis, such as spring forces, damping forces, inertial forces, and other position-based forces, as disclosed in co-pending patent application Ser. No. 09/______ entitled, "Haptic Feedback for Directional Control Pads." In addition, 3-D elevations can be simulated in the graphical environment by moving the pad to different elevations along the z-axis. If the pad **16** can be used as an analog input depending on the distance the entire pad is moved along the z-axis, and/or if kinesthetic (force) feedback is applied in the z-axis degree of freedom, then a greater range of motion for the pad **16** along the z-axis is desirable. An elastomeric layer can be provided if the touchpad **16** is able to be pressed by the user to close a switch and provide button or switch input to the computer **10** (e.g. using contact switches, optical switches, or the like). If such z-axis movement of the pad **16** is allowed, it is preferred that the z-axis movement require a relatively large amount of force to move the pad at least initially, since such z-axis movement may not be desired during normal use of the pad by the user.

[**0046**] The voice coil actuator **54** preferably includes a coil and a magnet, where a current is flowed through the coil and interacts with the magnetic field of the magnet to cause a force on the moving portion of the actuator (the coil or the magnet, depending on the implementation), as is well known to those skilled in the art and is described in copending application Ser. No. 09/156,802, incorporated herein by reference. Other types of actuators can also be used, such as a standard speaker, an E-core type actuator (as described in copending application Ser. No. 09/431,383, incorporated herein by reference), a solenoid, a pager motor, a DC motor, moving magnet actuator (described in copending provisional application Ser. No. 60/133,208 and patent application Ser. No. 09/431,383, both incorporated herein by reference), or other type of actuator. Furthermore, the actuator can be positioned to output linear motion along an axis perpendicular to the z-axis or along another direction different from the z-axis (rotary or linear), where a mechanism converts such output motion to linear motion along the z-axis as is well known to those skilled in the art.

[**0047**] The touchpad **16** can also be integrated with an elastomeric layer and/or a printed circuit board in a sub-assembly, where one or more actuators are coupled to the printed circuit board to provide tactile sensations to the touchpad **16**. Helical springs can also be provided to engage electrical contacts. Or, multiple voice coil actuators can be positioned at different locations under the touchpad **16**. These embodiments are described in copending application Ser. No. 09/______ entitled, "Haptic Feedback for Directional Control Pads." Any of the actuators described in that copending application can also be used in the present invention.

[**0048**] **FIG. 6** is a side elevational view of a third embodiment **60** of the haptic touchpad **16** of the present invention. In this embodiment, the stationary portion of the actuator is coupled to the touchpad **16**, and the moving portion of the actuator is coupled to an inertial mass to provide inertial haptic sensations.

[**0049**] Touchpad **16** can be compliantly mounted to the rigid housing of the computer device similarly to the embodiments described above. For example, one or more spring elements **62** can be coupled between the touchpad and the housing. These springs can be helical or leaf springs, a compliant material such as rubber or foam, flexures, etc.

[**0050**] One or more actuators **64** are coupled to the underside of the touchpad **16**. In the embodiment of **FIG. 6, a** piezo-electric actuator is shown. One portion **66** of each actuator **64** is coupled to the touchpad **16**, and the other